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HABITAT MANAGEMENT SERIES FOR UNIQUE OR ENDANGERED SPECIES

by Mark Zarn, Research Biologist
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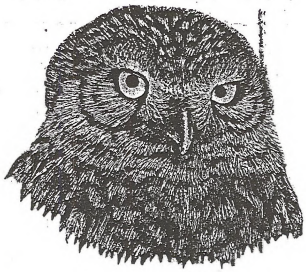
Report No. 11
Burrowing Owl
Speotyto cunicularia hypugaea



SCOTT RICHARD ROBINSON
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FOREWORD

This Technical Note series on wildlife is designed to provide a literature review and summary of current knowledge pertaining to endangered and other wildlife species occurring on public lands. We in the Bureau of Land Management have recognized the need for basic wildlife information in order to do an effective job in land-use planning. Sound planning must identify the negative aspects as well as the positive benefits of any proposed land management decision or program. It is our hope, too, that this series will also prove useful to others--be they land managers, students, researchers or interested citizens.

Ernest Berklund

Director
Bureau of Land Management
Department of the Interior

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Introduction

The objective of this report is to provide BIM personnel with the latest and most up-to-date information on rare or endangered species occurring on the public domain. This will provide a tool for improved understanding of the interrelationships between the species and its environment and encourage an end product of enlightened land management which will fully consider the species' welfare in all management decisions.

Species Description

The burrowing owl (Speotyto cunicularia hypugaea) is a small, readily identified bird of the western deserts, prairies and plains (Figure 1). Adult color consists of dull brown, barred and spotted with buff and white dorsally, with white barring on the wings and tail. The underparts are buffy, barred with brown. Burrowing owls have yellow eyes and compact, rounded heads lacking ear tufts. White markings on the chin and over the eyes are exhibited in courtship and territorial displays, most often by the male.

Short, hairlike feathers cover the long, slender tarsi of the burrowing owl and grade into sparse bristles on the gray-colored feet. The tail is short (75-90 mm) and the wings are large; wing length averages 168.7 mm in males and 165.8 mm in females (Earhart and Johnson, 1970). Body length is 230-280 mm (Bent, 1938; Jewett et al., 1953; Grossman and Hamlet, 1964; Ligon, 1961; Sumner and Dixon, 1953; Bailey and Niedrach, 1965).

The burrowing owl is the only North American strigiform not exhibiting reversed size dimorphism. Males weigh an average of 158.6 (range 120-228) grams, while females average 150.6 (range 129-185) grams (Earhart and Johnson, 1970). It is possible to sex adults in the field on the basis of behavioral differences and song in spring and early summer. Feather coloration is a less useful criterion, difficult to apply when observing single owls. Generally, females exhibit more ventral barring, while males appear lighter and more grayish in color from February to the postnuptial molt in August. Thomsen (1971) attributed this differential coloration to greater fading and wear of male plumage. Only females develop a brood patch. Juveniles below the age of six months exhibit no sexual dimorphism (Bailey and Niedrach, 1965; Coulombe, 1971; Thomsen, 1971; Butts, 1973; Martin, 1973a, personal communication).

Grayish-white down covers newly-hatched juveniles only on the feather tracts. This scanty down gives way to juvenile plumage of plain grayish to buffy brown dorsally, with light buff wing

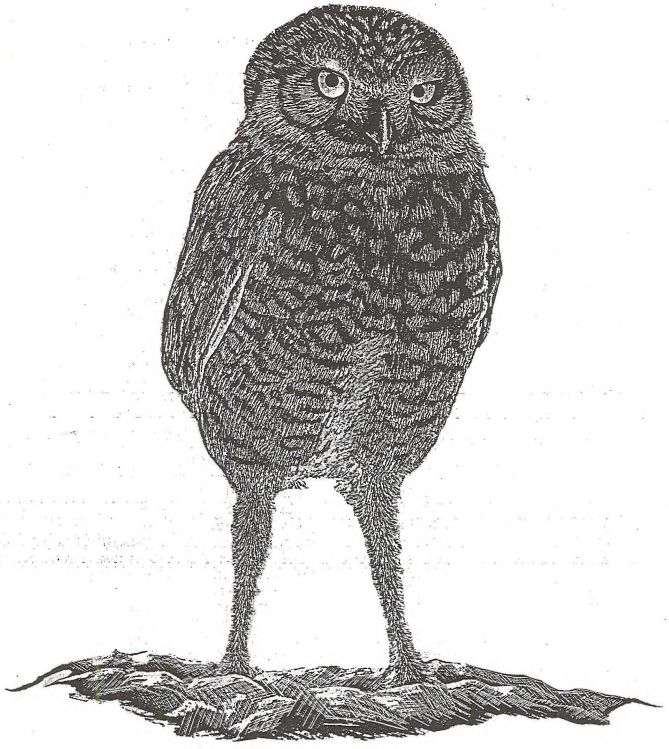

Figure 1
Burrowing owl, Speotyto cunicularia hypugaea

coverts showing less spotting than is present in adult plumage. The underparts and upper tail coverts are sandy and only faintly barred. Juveniles undergo a complete molt in late summer and by the end of September they exhibit largely adult plumage.

Most often, one sees burrowing owls on the ground at or near the burrow; they may also perch nearby on a low bush, fence post or other observation point. Burrowing owls characteristically bob up and down when disturbed (Bent, 1938; Jewett et al., 1953; Grossman and Hamlet, 1964; Ligon, 1961; Sumner and Dixon, 1953; Bailey and Niedrach, 1965).

Status and Population Trend

The U. S. Department of the Interior presently lists the burrowing owl as a "status-undetermined" species (U. S. Department of the Interior, 1973). It was listed as "rare" in the 1966 edition of the USDI Red Book and did not appear in the 1968 edition.

Estimates of burrowing owl numbers remain unavailable for most areas. Butts (1973) derived a population estimate of 543 burrowing owls in a 5100 square kilometer study area in the eastern one-third of the Oklahoma panhandle in 1970. Density figures probably contribute little to determining the status of the species, since clumping of owl populations occurs in association with burrowing mammal colonies. The widespread eradication of colonies through mammal damage control activities and outright habitat destruction have been and probably will continue to be significant factors in determining the size of burrowing owl populations in the West (Bent, 1938; Bailey and Niedrach, 1965; Ligon, 1961; Phillips et al., 1964; Sosebee, 1971; Martin, 1973a, personal communication; Marti, personal communication; Coulombe, personal communication; Olendorff, 1973; Butts, 1973).

Distribution

Speotyto cunicularia hypugaea breeds as far north as southern Canada from interior British Columbia east to south-central Manitoba, and as far south as central Mexico. The eastern limit of the breeding range lies roughly along a line from Manitoba to northwest Louisiana.

The winter range of this subspecies includes the southern portions of the breeding range, especially Texas, southern Louisiana and Mississippi, and western Florida, and extends south through central Mexico and western Central America to western Panama (American Ornithologists' Union, 1957; Peters, 1964).

Figure 2. Distribution of the burrowing owl, Speotyto cunicularia hypugaea, in the United States.

Life History

By failing to note any patterns of nocturnal activity in burrowing owls, or by emphasizing daily activity patterns, many authors have created the impression that this species is primarily diurnal and crepuscular in its habits (Bent, 1938; Gabrielson and Jewett, 1940; Jewett et al., 1953; Phillips et al., 1964; Bailey and Niedrach, 1965). Martí (1970) describes the burrowing owl as a small raptor adapted for foraging at lower light levels than other diurnal species. Sosebee (1971), in describing activity levels in Texas, conducted his investigations only from sunrise to sunset. But he did mention intense predawn feeding activity which diminished greatly after sunrise. Other observers have indicated that nocturnal activity may be more important in burrowing owls than previously believed. In some areas burrowing owls appear to exhibit seasonal changes in daily activity patterns, possibly in response to changes in climate and the prey base (Best, 1969; Coulombe, 1971; Butts, 1973). Martin (personal communication) feels that burrowing owls are well suited for nighttime foraging, and that nocturnal activity constitutes an important part of their behavior.

The burrowing owl consumes mostly insects and small mammals. Martí (1969) found the mean prey weight in burrowing owl pellets from northeastern Colorado to be six grams, but 85.9 percent of the food items weighed less than five grams.

In Iowa (Errington and Bennett, 1935), major vertebrate prey of the burrowing owl included meadow voles (Microtus spp.), deer mice (Peromyscus spp.), harvest mice (Reithrodontomys spp.), jumping mice (Zapus spp.), house mice (Mus spp.), ground squirrels (Spermophilus spp.), frogs, and small birds. Ground beetles (Coleoptera: Carabidae) outnumbered other invertebrate prey, but dung beetles (Scarabaeidae), carrion beetles (Silphidae), click beetles (Elateridae), and tiger beetles (Cicindelidae) were also consumed. Scott (1940) found that dung beetles formed a substantial portion of burrowing owl diet in Clay County, Iowa. Clay County owls also consumed deer mice and ground beetles.

In northeastern Colorado, burrowing owls prey on ground beetles, dung beetles, crickets (Gryllidae), short-horned grasshoppers (Locustidae=Acrididae), deer mice, meadow voles, and cottontail rabbits (Sylvilagus spp.) (Martí, 1970, 1974). Short-horned grasshoppers formed a significant proportion of the invertebrate prey items in the San Luis Valley of southern Colorado (Longhurst, 1942).

Scorpions (Scorpionidae), dung beetles, short-horned grasshoppers, ground beetles, pocket mice (Perognathus spp.), and kangaroo rats (Dipodomys spp.) made up the food items occurring most frequently in burrowing owl pellets taken from Maricopa County, Arizona (Glover, 1953). In central Oregon, the sage vole (Lagurus curtatus) was the most important prey species year-long, but especially so in autumn and winter. Great Basin pocket mice (Perognathus parvus), deer mice, and northern pocket gophers (Thomomys talpoides) also sustained heavy winter predation. Beetles and locusts formed the most important insect prey (Maser et al., 1971).

Burrowing owls utilize a much wider variety of both vertebrate and invertebrate prey than indicated above. They also take other small mammals, birds (including members of their own species), reptiles, amphibians, fish, crustaceans, insects and other invertebrates (Bent, 1938; Grossman and Hamlet, 1964; Maser et al., 1971; Bond, 1942; Robinson, 1954; Thomsen, 1971; Longhurst, 1942; Marti, 1969, 1970, 1974; Errington and Bennett, 1935; Best, 1969; Butts, 1973). Local conditions can affect both the relative proportions and species diversity of food items utilized. In Nevada, Bond (1942) found the remains of thirty spadefoot toads (Scaphiopus spp.) in twelve pellets around one occupied burrow. Scaphiopus remains occurred in 100 percent frequency in pellets from a burrow in Clark County, Kansas (Sperry, 1941). In Denver, Colorado, crayfish (Cambarus spp.) formed the most conspicuous prey remains at two burrows, while the nearest source for this prey was over one mile distant (Hamilton, 1941).

Simple availability may account for the relative frequency of occurrence of food items in owl pellets (Glover, 1953; Errington and Bennett, 1935), but the great seasonal variation in diet exhibited by burrowing owls is probably influenced by several other factors. Changes in faunal or floral composition may affect prey availability in several ways. Burrowing owls in many areas depend on vertebrate prey from late fall through early spring, probably because few invertebrates are available (Maser et al., 1971; Best, 1969; Butts, 1973; Ross, 1970). Tall or dense vegetation may hinder owls from feeding on certain prey items in summer (Errington and Bennett, 1935; Best, 1969), while decreased vegetative cover may increase the vulnerability of rodents and birds to winter predation (Butts, 1973). The experience of the individual owl may determine the types of prey it is able to capture. Errington and Bennett (1935) noted a dramatic shift in diet from primarily vertebrates to mostly arthropods in early August, about the time that young-of-the-year began to forage for themselves. This may simply have reflected an upswing in arthropod populations, or it may have indicated that young birds were less adept at preying on

vertebrates than were their parents. Marti (1970, 1974) states that individuals unfamiliar with their environment, as during migration or dispersal of young, may be more susceptible to predation. Lack of food or adverse weather conditions may make birds more available to owls in winter (Butts, 1973). Changes in behavioral and daily activity patterns of predator and prey also occur throughout the year. Adults caring for a brood may forage longer, taking prey not otherwise available to them. Prey species that hibernate of course become seasonally unavailable (Marti, 1970, 1974). The absence of insects during winter in some areas forces owls present to more heavily utilize mammals, most of which are nocturnal. In fact, several investigators in such areas have documented shifts to almost exclusive nocturnal activity by burrowing owls in winter months, which seem to be related to foraging activity (Best, 1969; Butts, 1973; Coulombe, 1971).

On a diet of laboratory mice, a captive adult burrowing owl consumed an average of 26.4 grams, or 15.9 percent, of its body weight daily. Daily pellet formation rates averaged 1.5, with 18.1 grams of food consumed for each pellet formed (Marti, 1973). Adult wild burrowing owls may form pellets at twice the rate of captives, since wild owls are more active (Marti, 1970). Burrowing owls bringing food to their two young supplied them with 22 grasshoppers, 17 beetles, 2 lizards, 1 frog and 1 jumping mouse in a single one-hour-and-forty-minute period (Walker, 1952).

Burrowing owls utilize four basic hunting methods: ground foraging, hovering, observational foraging, and flycatching. In ground foraging, the owl pursues prey animals over the ground in a manner similar to that of the robin, hopping upon them and crushing them with its bill. The prey is immediately eaten or carried in the bill to the burrow, sometimes being transferred from the talons to the bill in flight (Martin, 1973a). Hovering behavior is similar to that characteristic of the American kestrel (Falco sparverius). The owl hovers from 8 to 30 meters above the ground until it spots the prey, and then stoops to the prey, pinning it to the ground with the talons. Observational foraging consists of perching at an elevated position or gliding about one meter above the ground, and flying to or dropping on the prey. In one instance an owl perched twenty-five feet from the ground recovered a Jerusalem cricket (Stenopelmatus spp.) from 100 yards away (Thomsen, 1971). In flycatching, burrowing owls pursue flying insects through the air and catch them in their talons (Coulombe, 1971; Thomsen, 1971; Martin, 1973a; Marti, 1970, 1974; Bent, 1938; Robertson, 1929; Butts, 1973).

Burrowing owls pin prey to the ground rather than grasping it in their talons as many hawks do. This reduces the accuracy required to capture prey under poor light conditions, or when prey is concealed. Talon spread in the burrowing owl is 75 x 50 mm (Goslow, 1967; Marti, 1970, 1974).

Burrowing owl pellets are cylindrical in shape, with blunt, rounded ends. They measure 30-40 mm in length, 15 mm in diameter, and weigh slightly over one gram when dry. Color ranges from gray to brown, and in the warmer months the pellets may be quite fragile and consist almost entirely of insect parts. Since the owls pick at their food as they eat, badly crushed and broken prey remains characterize burrowing owl pellets (Murie, 1954; Maser et al., 1971; Marti, 1969; Thomsen, 1971; Martin, 1971; Best, 1969).

The most unique aspect of the life history of burrowing owls is the burrow, which plays an important role in nesting, shelter, protection from predators, food supply, thermoregulation, social interaction, and population dynamics (Thomsen, 1971; Coulombe, 1971).

Burrowing owls apparently can excavate their own burrows, at least under some conditions, but usually depend for burrow "starts" on colonial burrowing mammals, especially ground squirrels (Spermophilus spp.) and prairie dogs (Cynomys spp.). They also utilize burrows dug by other animals, including badgers (Taxidea taxus), marmots (Marmota spp.), skunks (Mephitis spp., Spilogale spp.), armadillos (Dasypus spp.), muskrats (Odonatra zebithicus), banner-tail kangaroo rats (Dipodomys spectabilis), and tortoises (Gopherus spp.) (Bent, 1938; Grossman and Hamlet, 1964; Platt, 1971; Coulombe, 1971; Martin, 1973a; Jewett et al., 1953; Bailey and Niedrach, 1965; Longhurst, 1942; Ligon, 1961; Olendorff, 1973; Thomsen, 1971; Best, 1969; Butts, 1973). In one instance owls occupied holes gnawed into haystacks by feeding jackrabbits (Lepus spp.). No evidence indicated the owls had used these burrows for nesting (Stoner, 1933).

Burrow entrance dimensions vary greatly. In the case of burrows originally excavated by smaller mammals, burrow age probably determines entrance size. The inner tunnel exhibits greater size uniformity, averaging 11 x 20 cm, and roughly corresponding to the size of an adult owl (Coulombe, 1971; Martin, 1973a). Orientation of the burrow opening shows no correlation with compass direction. One encounters burrows in a variety of locations, from cut banks and arroyos to grasslands, prairies, urban areas, and airports, usually in open situations (Abbott, 1930; Sumner and Dixon, 1953; Coulombe, 1971; Thomsen, 1971; Best, 1969; Butts, 1973; Martin, 1973a). Most burrows slant

downward from the entrance at an approximate 15° angle. The length of the tunnel varies greatly but rarely drops below 1.5 meters in length. The nest is in an enlarged cavity at the end of the tunnel (Bent, 1938; Ligon, 1961; Coulombe, 1971; Best, 1969; Martin, 1973a).

Burrowing owls characteristically line the burrow entrance, the tunnel, and the nest cavity with shreds of dried cow or horse dung, and sometimes with weedstalks, grass, feathers, or portions of prey items (Bent, 1938; Platt, 1971; Bailey and Niedrach, 1965; Grossman and Hamlet, 1964; James and Seabloom, 1968). Owls in a population resident at the Oakland Municipal Airport, California, used divots from a nearby golf course in place of dung (Thomsen, 1971). The dung may serve as an insulator and absorbent material (Bailey and Niedrach, 1965; Martin, 1973a), or as an aid to incubation (Best, 1969). Martin (1973a) further postulates that it may serve to mask the owl's scent and perhaps that of its prey from potential terrestrial predators. If man removes the feces from the tunnel entrance, the owls replace them within one day.

Pair formation in migratory owl populations begins upon arrival at the nesting grounds in March and April. In Oakland, California, resident owls begin pair formation in December, and most breeding owls have paired by late February. Display consists of primary song (described on page 13) given by the male at a burrow entrance from sunset and continuing throughout the night (Coulombe, 1971; Thomsen, 1971; Martin, 1973a; Best, 1969).

Courtship behavior begins in migratory populations in New Mexico in mid-March and continues until mid-April. It involves varied postures, vocalizations and displays by both sexes; some of these include mutual preening, scratching and nipping, and leg- and wing-stretching. Courtship behavior usually occurs within 15 meters of the burrow.

Copulatory behavior also centers around the burrow. The male raises his feathers, stands erect, and displays his white facial patches while giving the primary song. The female elicits this behavior by running or flying a short distance from the burrow, returning after a few moments. Copulation takes place after several repeats of this performance. Copulatory behavior generally ceases by mid-April (Coulombe, 1971; Thomsen, 1971; Martin, 1973a; Butts, 1973).

Selection of the nest burrow occurs after a pair of owls has formed. Burrows once modified by burrowing owls are often reused, but not necessarily by the same individuals. Both members of a pair renovate the burrow by digging and scratching before

adding nesting material. They use the beak as well as the feet and wings, as evidenced by the presence of inorganic material in pellets which corresponds to the substrate in which the owls are digging. Burrowing owls initiate burrow renovation at several burrows but gradually concentrate their efforts and eventually select a single burrow for the nest site. They also utilize several satellite burrows, in proximity to the nest burrow, for perching and observation (Bent, 1938; Best, 1969; Martin, 1971, 1973a; James and Seabloom, 1968; Thomsen, 1971; Butts, 1973).

Burrowing owls exhibit only intraspecific territoriality, and establish territories coincident with pair formation. The first stage of territorial display consists of primary song given by the defending male. If this proves unsuccessful, he presents himself to the intruder, silently and with no fighting. Burrowing owls rarely employ the final stage, physical contact. The territory surrounds the burrow, with boundaries lying roughly equidistant between two adjoining burrows, and thus does not include the foraging areas. Territory defense may continue until fledging (Thomsen, 1971; Martin, 1973a; Butts, 1973). Thomsen estimated that territory size averaged 1.98 (range 1.0 - 4.0) acres in her study area. Martin (1973a) found considerably larger territories in his study populations; spacing between neighbors averaged 166 meters. In Oklahoma, territories of some individual nesting pairs were smaller than 0.1 acre. Twice as many territorial conflicts occurred in an area with one nest per 0.7 acres as in an area with one nest per 1.7 acres (Butts, 1973).

Females lay eggs from late March to early May, usually during the latter part of this period. Clutch size varies from six to eleven, averaging seven to nine. Incubation lasts about four weeks. Only the female develops a brood patch, and she does all the incubating, becoming very secretive. The male remains near the burrow entrance by day, and brings food to the female in the early morning and evening (Bent, 1938; Coulombe, 1971; Thomsen, 1971, Howell, 1964; Martin, 1973a; Grossman and Hamlet, 1964; Bailey and Niedrach, 1965).

The young emerge to stand at the burrow entrance and wait for the parents to bring them food when they reach about two weeks of age. At three weeks of age they run about, preening, stretching, and flapping their wings. At this time they begin to practice prey-killing by hopping upon and crushing dead insects. All of these activities improve their coordination until they begin flying, at four weeks. At six weeks they can fly quite well, but remain within fifty meters of the burrow.

During this developmental period one adult, often the female, remains near the burrow while the other gathers food for the young. The male obtains most of the food, while the female helps distribute it.

As the young mature they begin to accompany the parents on foraging flights. In late summer the entire family group often leaves to forage together. At first the young do little to obtain their own food, but later become more independent and spend increasing amounts of time alone at other burrows. By September, pairs, families and colonies begin to break up. During the winter months burrowing owls are more often seen singly, and they display much lower burrow site specificity until the following spring (Thomsen, 1971; Coulombe, 1971; Martin, 1973a; Best, 1969; Butts, 1973).

Burrowing owls have many potential predators. Among these are skunks, badgers, coyotes (Canis latrans), bobcats (Lynx rufus), barn owls (Tyto alba), and snakes. They display against humans, domestic dogs and cats, weasels (Mustela spp.), prairie falcons (Falco mexicanus), red-tailed hawks (Buteo jamaicensis), Swainson's hawks (B. swainsoni), ferruginous hawks (B. regalis), marsh hawks (Circus cyaneus), golden eagles (Aquila chrysaetos), and great horned owls (Bubo virginianus) (Bent, 1938; Coulombe, 1971; Thomsen, 1971; Martin, 1973a; Gretz, 1971; Butts, 1973).

Burrowing owls vary seasonally in their response to predators, probably because of the high vulnerability of eggs and young. Between October and February, burrowing owls approached by predators crouch down, run to a burrow, or fly away quietly. From March to May the owls run into the nest burrow after one of them has given an alarm call. Beginning in June either parent may give the warning call, and the young run into the burrow, usually followed by the female. The male remains outside unless the attacker is another raptor. The male often mobs a terrestrial predator. If the predator continues to advance, the male owl flies between areas about 100 meters away from the burrow, inducing the predator to follow him. Having led the predator a sufficient distance from the burrow, the male returns to it. If the predator approaches the burrow in spite of these displays, the owls attack, chattering and screaming, and dive boldly at the predator from behind. Young owls cornered inside or outside the burrow will crouch down, rotate their wings, and rasp in the characteristic owl defense posture. This defensive behavior occurs until the juvenile owls reach independence. Burrowing owls also mob potential predators trespassing on their territory. Juveniles able to fly and even other owls from territories as far as 300 meters away join in. During mobbing activities, observers have seen no territorial displays by male burrowing owls (Martin, 1973a).

In turn, other bird species harass burrowing owls. These include American robins (Turdus migratorius), red-winged blackbirds (Agelaius phoeniceus), cliff swallows (Petrochelidon pyrrhonata), western meadowlarks (Sturnella neglecta), mockingbirds (Mimus polyglottos), American kestrels (Falco sparverius), and American avocets (Recurvirostra americana) (Thomsen, 1971).

Burrowing owls consistently associate with colonial mammals of the genera Spermophilus and Cynomys, whose burrows the owls utilize. Walker (1952) watched burrowing owls take over possession of a prairie dog's burrow when rain flooded their own. The adults hovered and dove at the evicted prairie dog if it approached within six meters of its burrow. Thomsen (1971) observed that ground squirrels (Spermophilus beecheyi) in her study area consistently lost in interactions with burrowing owls, although differing activity patterns kept the incidence of contact between the two species quite low.

Burrowing owl migratory habits remain unclear. Burrowing owls in northeast Arizona migrate (Phillips et al., 1964). In New Mexico, Martin (1973a) found that most owls in his study area migrated, or at least wandered extensively, from October to March. Best (1969) felt that burrowing owls shifted to total nocturnal activity in winter and tended to wander, using more than one burrow. In Oklahoma, a small fraction of the summer burrowing owl populations overwinters, often in pairs (Butts, 1973). Most burrowing owls in the vicinity of Oakland, California do not migrate (Thomsen, 1971), but Coulombe (1971) feels that some individuals of northern populations migrate to southern California in winter. It appears that at least some burrowing owls overwinter on their breeding grounds, and one account (Agersborg, 1885) even describes food caching and communal burrow utilization by wintering owls. Recent studies have failed to substantiate this account, however.

Reproductive success has varied in recently studied populations. Martin (1973a) observed only one non-breeding adult in a population of fifteen breeding pairs of burrowing owls in New Mexico. Reproductive success for this population averaged 4.9 young per pair. Thomsen (1971) continued her study for two breeding seasons. In the first year 15 breeding adults and 3 non-breeding adults comprised the population. Productivity averaged 4.4 young per breeding pair and 4.0 young per adult in the population, with a fledging success of 88.8 percent. In the second year, although 15 pairs attempted nesting, only 9 pairs produced young. Productivity dropped to 3.4 young per breeding pair and 2.0 young per adult in the population. Only five of 15 pairs (33.3 percent) fledged young. In Oklahoma,

brood size averaged 4.7, and 80 percent of 69 nests produced at least one fledgling. Eighty-eight percent of the fledglings survived through six weeks of age (Butts, 1973).

Thomsen (1971) felt that a late, short growing season coupled with increased shifting of mates and burrows, and more territorial clumping, may have limited burrowing owl productivity during the second year of her study. She stated that experience and pair stability, as well as stability in relation to other pair activities, contributes to reproductive success. Martin (1973a) believes that migratory behavior in the New Mexico population results in higher death and dispersal rates with resultant lower year-round population densities on the breeding grounds. This serves to increase the availability of limiting resources and therefore to augment burrowing owl productivity. Marti (1970) felt that migration in burrowing owl populations might be an adaptive mechanism for avoidance of competition (and therefore stress) at times of low food supplies.

Mortality factors other than predation operate against burrowing owls. Thomsen (1971) calculated a 30 percent total mortality (70 percent juvenile mortality, 19 percent adult mortality) for her study population from September 1964 through April 1965. Although unable to document direct causes of mortality, she suggested that factors might include predation, starvation, diseases and parasites, and accidents. Other potentially significant mortality factors operating in burrowing owl populations include highway mortality, burrow destruction through chaining or agricultural and construction activity, shooting, and accidental poisoning during rodent control operations (Bent, 1938; Scott, 1940; Platt, 1971; Thomsen, 1971; Ligon, 1961; Coulombe, 1971; Butts, 1973).

Burrowing owls' repertoire of about 17 vocalizations consists of 9 basic calls with 8 variations (Martin, 1973b). Primary song, given only by adult males when near their burrows, functions in pair formation, precopulatory behavior, and territory defense. It is a two-syllable call, similar in quality to that of a California quail (Lophortyx californicus), with the second note longer than the first. The call lasts slightly less than one second.

The rasp call sounds like radio static. Adult females rasp when distressed, when receiving food from the male, and when giving food to the young. Juveniles also use the rasp call in food begging. The rasp usually ceases within one second.

The chuck, a sharp, single note often associated with the bowing display, functions as a low-level warning call. It consists of a gradual upward slur, sounding as though composed of one low-pitched and one high-pitched note, with a duration of 0.08 - 0.10 seconds.

Burrowing owls employ the chatter call in more intense agonistic behavior.. It consists of a variable number of shortened chucks uttered in rapid succession.

The highest threat level that burrowing owls can express is uttered as a scream, a continuous, loud scratchy sound, higher in pitch than a rasp call. Duration, although highly variable, is usually less than 1.0 second.

Juveniles give the rattlesnake rasp under conditions of extreme distress. It serves as the precursor of the adult scream and when given from inside a burrow sounds like the rattling of a rattlesnake. This call is probably not a true mimic, as young saw-whet (Aegolius acadicus) and screech owls (Otus asio) also utilize it (Thomsen, 1971; Martin, 1973b).

Habitat Requirements and Limiting Factors

Burrowing owls were once common throughout the West. But they are declining in many areas of former abundance. Authorities attribute these major reductions in burrowing owl numbers to two principal factors: loss of burrow sites as a result of widespread burrowing mammal control activities and direct loss of habitat to urban, industrial and agricultural development (Bent, 1938; Bailey and Niedrach, 1965; Ligon, 1961; Phillips et al., 1964; Sosebee, 1971; Martin, 1973a, personal communication; Marti, personal communication; Butts, 1973, verbal communication).

Burrowing owls occur in a variety of habitats including deserts, grassland, prairies and plains, agricultural areas, and even airports. Three factors essential to good burrowing owl habitat in all areas are openness, short vegetation, and burrow availability (Best, 1969; Butts, 1973; Coulombe, 1971, personal communication; Marti, personal communication).

Although burrowing owls occasionally utilize other shelters, successful reproduction takes place mostly in burrows started by medium- to large-size rodents, particularly ground squirrels and prairie dogs, and modified by the owls (Coulombe, personal communication). Owls seldom utilize areas unoccupied by colonies of burrowing mammals. Butts (1973) found a population density of one adult owl per 4.8 acres of prairie dog town in

his Oklahoma study area, while the population density of owls living at least one mile from prairie dog towns was only one adult per 5683 acres. Most other studies of burrowing owls document their association with burrowing mammal colonies (Bent, 1938; Robertson, 1929; Robinson, 1954; Walker, 1952; Olendorff, 1973; Thomsen, 1971; Coulombe, 1971; Jewett et al., 1953; Bailey and Niedrach, 1965; Phillips et al., 1954; Ligon, 1961; Longhurst, 1942; Marti, 1969, 1970; Martin, 1973a).

Burrowing owls utilize many fewer burrows in abandoned prairie dog towns. In Oklahoma, deterioration of burrows abandoned after poisoning activities made them useless to the owls within one year. In areas where small prairie dog populations persisted after poisoning, burrowing owls utilized only burrows in the active remnants of the prairie dog towns (Butts, 1973).

Burrow availability operates as the major factor in controlling burrowing owl numbers (Coulombe, 1971; Marti, personal communication). Since territory size is larger and territorial behavior more complex for burrowing owls than for most social birds, and since burrowing owls occasionally nest in isolated locations, successful reproduction seems possible in the absence of social interaction. Therefore, clumping of burrowing owl populations in mammal colonies occurs probably more as a function of burrow availability than as a need for social interaction in the species (Best, 1969; Olendorff, 1973).

Brush control activity along irrigation canals in the Imperial Valley of California, and presumably elsewhere, exerts primary impacts on ground squirrel populations. Too frequent control disrupts colonization by ground squirrels; too little control allows vegetation to grow too tall for ground squirrels' habitat preferences. In either case, resultant burrow availability affects the owls (Coulombe, personal communication). In New Mexico, bank stabilization activities by the U. S. Army Corps of Engineers completely destroyed the burrowing owls in Martin's study population (Martin, 1973a, personal communication).

No one has yet studied the effects of pesticides and other agricultural chemicals on recruitment in burrowing owl populations. Since burrowing owls are primarily insectivorous during times when they forage most intensively in agricultural areas, effects of such chemicals on reproduction might conceivably become important (Coulombe, personal communication; Butts, 1973).

Rodent control, in addition to destroying preferred burrowing owl habitat, also results in secondary poisoning of the owls. Coulombe (personal communication) maintains that burrowing owls

consume carrion available to them near their burrows and feels that secondary poisoning of burrowing owls is important in the foothills of the central valley of California. Butts (1973) also acknowledges the importance of secondary poisoning to burrowing owls.

Since many people seem to find sport in using prairie dogs for target practice, and others shoot them in control attempts, burrowing owls naturally suffer shooting pressure by irresponsible and uninformed individuals due to their conspicuous presence in prairie dog towns. Butts (1973) found owls suffering from gunshot wounds in Oklahoma. Game bird hunters may also occasionally shoot burrowing owls by mistake (Coulombe, personal communication; Marti, personal communication).

While agricultural operations harm burrowing owls by decreasing available nest burrows, cropland may also benefit burrowing owl populations by augmenting food supplies. In Oklahoma, wheat fields grew on at least one side of prairie dog towns having dense populations of owls; conversely, lower densities of burrowing owls occupied prairie dog towns surrounded by grassland. Greater prey populations were found to be available to owls occupying prairie dog towns adjacent to cereal crops (Butts, 1973). Coulombe (personal communication) places burrowing owl populations into two categories: those occupying "natural" ecosystems (desert, prairie, and grazing land), and those occupying "subsidized" ecosystems (farmland or urban/suburban areas). He feels that caloric food availability does not limit burrowing owl populations in "subsidized" ecosystems, but that food availability might become limiting in "natural" ecosystems. Butts (1973) also mentions that grazing of land formerly vegetated with taller grasses probably makes more land suitable for colonization by ground squirrels and prairie dogs, and hence increases burrow availability for burrowing owls.

Another factor limiting burrowing owl numbers, habitat destruction through land development, has so far been significant mainly around urban population centers and in regions of agricultural importance. Much of the responsibility for wise land use in such areas rests with private individuals as well as with local and state government agencies and legislatures. Although burrowing owls can persist in close association with man (Abbott, 1930; Thomsen, 1971; Zarn, personal observation), it remains necessary to set aside areas for the undisturbed existence of wildlife in suitable habitat.

The Federal government is being called upon to exercise initiative and environmental responsibility in yet another area: the mining of coal and its concomitant resource development in the

West. Many problems remain to be solved in the realms of surface and underground water resources, increased human population impacts, air and water pollution, and perhaps most importantly, land reclamation and revegetation. To preserve populations of burrowing owls on strip-mined lands, the re-establishment of burrowing rodents is of primary importance. But the establishment of burrowing rodents will depend on providing elevated areas of suitable soil type and compaction, and furthermore, on insuring adequate types, patterns, and rates of vegetational establishment (Coulombe, personal communication). Sound planning for land reclamation must accompany development of such a major national resource.

Protective Measures Instituted

As yet, no legal measures exist to specifically protect burrowing owls, other than regulations protecting all other raptors as well. However, in areas where black-footed ferrets (Mustela nigripes) are believed to occur, restrictions on prairie dog control activities may incidentally protect burrowing owls. No control of prairie dogs may be undertaken on BSF&W National Wildlife Refuges in Region 3 (Colorado, Iowa, Kansas, Missouri, Montana, Nebraska, North Dakota, South Dakota, Utah, Wyoming) without permission of the Regional Director. Furthermore, Interior Department personnel may not undertake prairie dog control in any area until it is certified to be free of ferrets (Snow, 1972; Henderson et al., 1969). The Colorado State Office of the Bureau of Land Management has allowed no control of prairie dogs on BLM lands within the state since 1970. Thirty-two sections of land in the Grand Junction District, Colorado, have been designated as a "no-shooting" protective area for prairie dogs. And roads and drill sites for oil and gas exploration on BLM lands in Colorado must be located away from prairie dog towns (D. R. Andrus, Colorado State Director, BLM, personal communication). The U. S. Department of Agriculture and the Department of Defense also require pre-control ferret surveys on lands which they administer (Snow, 1972; Henderson et al., 1969).

Species and Habitat Management Recommendations

1. Preserve colonies of burrowing mammals in areas where control is not critical and where high concentrations of burrowing owls persist. Establish refuges for both colonial burrowing mammals and burrowing owls at regular intervals throughout their range, especially on all suitable National Wildlife Refuges, National Parks and Monuments, National Grasslands, and other public lands including state school lands (Butts, 1973).

2. In areas where damage by burrowing mammals must be avoided, set up definite boundaries such as fences, mark the area as protected, exercise control outside the protected zone, and reimburse landowners for damages incurred (Olendorff, 1973; Marti, personal communication; Butts, 1973).

3. When forced to control prairie dogs or ground squirrels, use non-lethal methods, such as transplanting, wherever possible.

4. When planning lethal control of burrowing mammals, survey the area thoroughly during the owl nesting season to determine the presence of burrowing owls. Search for nesting burrows as well as for the owls themselves, especially if conducting the survey around midday, during periods of high temperature, or when wind velocity exceeds 15 km per hour. Nest burrows are easily identified by the presence of owl droppings and tracks, prey remains, and a burrow lining of dried animal feces. Where burrowing owls are migratory, surveys to determine their presence would have very little value from October through March (Butts, 1973).

5. Restrict poisoning of burrowing mammal colonies with treated grain to January and February to minimize deleterious effects on burrowing owls (Butts, 1973).

6. If poisoning of burrowing mammal colonies proves necessary during late spring and summer, restrict control activities to fumigation of burrows unoccupied by burrowing owls (Butts, 1973). (See recommendation number 4, above, for characteristics of burrowing owl nest burrows.)

7. Test methods of establishing burrowing owls on burrowing mammal preserves, as through transplanting of entire owl broods to such areas (Butts, 1973).

8. Investigate the possibilities of maintaining burrowing owls in the absence of burrowing mammal populations.

9. Minimize damages to burrowing owls where burrowing mammals are shot for sport through education emphasizing the esthetic, historic, scientific, and ecological values of burrowing owls (Butts, 1973; Marti, personal communication).

Authorities

1. Kenneth O. Butts, Wildlife Biologist (Oklahoma)
U. S. Fish and Wildlife Service
17 Executive Park Drive, N. E.
Atlanta, Georgia 30329

2. Dr. Harry N. Coulombe (California)
Department of Biology
San Diego State University
San Diego, California 92115

3. Dr. Carl D. Marti (Colorado)
Department of Zoology
Weber State College
Ogden, Utah 84403

4. Dennis J. Martin (New Mexico)
Department of Biology, UMC 53
Utah State University
Logan, Utah 84322

Summary

Burrowing owls are small, easily identified ground-dwelling owls of western deserts, prairies and plains. Males are larger than females and average 158.6 grams in weight. Females weigh about 150.6 grams. Body length is 230-280 mm. The sexes differ in behavior and feather coloration, criteria for field determination of adult gender.

Although estimates of burrowing owl numbers remain largely unavailable, the species is believed to be declining throughout most of its range due to loss of preferred nesting habitat through land development and extensive rodent control activities.

Burrowing owls have a widely varied diet, but usually select as prey insects and rodents weighing less than five grams. Their diet varies seasonally as a result of changes in floral and faunal composition, individual experience in procuring prey, changes in the number of potential prey individuals unfamiliar with their surroundings, and changes in behavioral and daily activity patterns by both predator and prey. A captive adult burrowing owl consumed 16 percent of its body weight daily.

The species utilizes four basic hunting methods: ground foraging, hovering, observational foraging, and flycatching, and is adapted to pin prey to the ground, an advantage when foraging in dim light or when capturing concealed prey.

The burrow dominates much of the ecology of the burrowing owl, functioning in nesting, shelter, protection from enemies, food supply, thermoregulation, social interaction and population dynamics. Burrowing owls exhibit a high degree of association with colonial burrowing mammals, particularly prairie dogs (Cynomys spp.) and ground squirrels (Spermophilus spp.). Although capable of digging their own burrows under some conditions,

burrowing owls depend heavily on the pre-excavated burrows of these mammals for "starts," although they occasionally use other types of burrows as well. Burrowing owls characteristically line their nest burrows with shreds of dried horse or cow feces.

Courtship and mating behavior usually takes place from March to mid-April. Owls lay eggs from late March to early May; clutch size averages seven to nine eggs. Incubation takes about twenty-eight days and is accomplished exclusively by the female.

The young emerge from the burrow at about two weeks of age and fly well when about six weeks old. During this period of development the male obtains most of the food and the female helps distribute it. As the young mature they become more independent and spend increasing amounts of time alone at other burrows. Family groups and colonies begin to disperse by September.

Burrowing owls vary seasonally in their response to predators, probably because of the high vulnerability of eggs and young to predation. Defense techniques include warning and threat vocalizations, decoy behavior, and mobbing.

The species' migratory habits remain unclear. Generally, burrowing owls in northerly areas winter in the southern portions of the range, though at least some individuals may overwinter on the breeding grounds. Resident owls tend to wander extensively and may become almost strictly nocturnal during the winter months.

Reproductive success is influenced by pair stability, experience in raising young, territory shifting, and the migratory habits of the population. Mortality factors include predation, burrow destruction, shooting, highway mortality, poisoning, starvation, diseases and parasites, and accidents.

While burrowing owls live in a wide range of communities, openness, short vegetation, and burrow availability form essential components of optimum habitat in all situations.

Burrow availability operates as the chief limiting factor in controlling burrowing owl numbers. Burrowing owls seldom utilize areas devoid of burrowing mammal colonies. Furthermore, they depend primarily on active burrowing mammal colonies for nest burrow sites.

Other limiting factors include brush control and bank stabilization activities, effects of pesticides on recruitment, secondary poisoning through rodent control activities, accidental

and deliberate shooting, and food availability. In future years, the development of western coal resources may further reduce the numbers of this uniquely adapted species. To preserve and maintain viable populations of burrowing owls on surface-mined lands, it will first be necessary to reestablish colonies of burrowing mammals in these areas. This will depend on providing elevated areas of suitable soil type and compaction, and on insuring adequate types, patterns and rates of vegetational establishment.

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